Effect of self-organization and properties of aqueous disperse systems based on the moss peptide PpCLE2 in a low concentration range on the growth of *Arabidopsis thaliana* roots*

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It is shown for the first time using a complex of physicochemical methods (dynamic and electrophoretic light scattering, conductometry, pH-metry) that below a threshold concentration of $1.0 \cdot 10^{-7}$ mol L^{-1} the disperse phase of the aqueous systems based on moss peptide PpCLE2 undergoes the domain—nanoassociate rearrangement, which affects the nonmonotonic concentration dependences of the specific electrical conductivity and pH and can result in a multidirectional profile of the dependence of the growth of the primary and lateral roots of the *Arabidopsis thaliana* seed plant in the range of calculated concentrations from $1.0 \cdot 10^{-6}$ to $1.0 \cdot 10^{-12}$ mol L^{-1}.

Key words: aqueous disperse system, low concentrations, moss peptide PpCLE2, nanoassociates, domains, nonmonotonic dependences, physicochemical properties, bioeffect sign change, *Arabidopsis thaliana*.

It has recently been found that dilute aqueous solutions of many biologically active substances (BAS) in a wide range of calculated concentrations ($1 \cdot 10^{-20}$—$1 \cdot 10^{-6}$ mol L^{-1}) represent self-organized disperse systems with the disperse phase composed of scaled nanosized molecular ensembles (up to 400 nm, ζ-potential from −2 to −20 mV) named nanoassociates.[1,2] It was established on the basis of an array of experimental data that the formation of nanoassociates and their precursors, supramolecular domains formed in the range of higher concentrations, results in the appearance of nonmonotonic concentration dependences of the physicochemical properties and, which is especially important, correlates with biological activity of these systems. The extreme values of parameters of the nanoassociates, physicochemical properties, and bioeffects are observed in almost the same concentration ranges. This made it possible to advance a hypothesis,[1,2] according to which the nonmonotonic character of the bioeffect, change in its sign (hormesis), and the existence of "silence zones" are related to the transformation of the disperse phase supramolecular domain—nanoassociate and rearrangement of nanoassociates accompanied by a change in their parameters, *viz.*, physicochemical and biological properties of the system.

To the present time, we established an interrelation between the formation and rearrangement of the disperse phase and nonmonotonic concentration dependences of the bioeffects characterized by the sign change and "silence zones" in the range of low concentrations in the systems based on synthetic regulators of plant growth Melafen[3] and Guanibiphos,[4] salicylic[5] and *p*-aminobenzoic acids,[6] macrocyclic regulators of energy exchange of plants,[7,8] bacteriostatic drugs,[9,10] tranquilizer mebikar,[11] phenol antioxidants,[12,13] immunomodulator polyoxidonium,[14,15] and hormonal neuropeptide thyroliberin.[16]

As determined on the basis of the commonly accepted ligand—receptor concepts on bioregulation, the direct binding of the regulatory BAS molecule (ligand) with the receptor is necessary for the induction of the cellular reaction. However, from the viewpoint of the ligand—receptor kinetics, the action of low concentrations of BAS can hardly be explained.[17] The contradiction between the

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